

Model-based Diagnostics for Wire Health Management

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Wire chafing in aircraft has previously been identified as the largest source of failure in electrical wiring systems by the FAA, NAVAIR and the Coast Guard. Although significant progress has been made in the identification of hard faults such as short and open circuits, soft fault assessment remains elusive. By soft fault assessment, we mean quantification of the degradation in wiring insulation thickness prior to a full short or open circuit condition as might occur when insulation becomes thinner during chafing.

We have developed a soft fault assessment technique using physics-based modeling. We differentiate when it is and is not practical to discern the variation of thickness of insulation along a wire based upon the modeled physics in the presence of faults, vibrations and bends. Previous efforts have concluded that it may be too difficult to distinguish faults by comparing reflection responses by eye as opposed to quantifying model parameters. Through the means of electrical interrogation, we can infer model parameters representing the state of health along the full length of a harness. As an example, we examine a typical analog sensor harness (such as hydraulic sensors in a landing gear system).

Typical model inversion efforts in the past have relied upon either lumped parameter transmission line theory and/or mathematically convenient assumptions in order to make the system of equations tractable. In our approach, all assumptions come from the expected type of faults and use a continuous compact Green's function representation. Note that these are not standard Green's functions, in that these are compact in both space and time. We demonstrate our inversion system on a physical test-bed undergoing severe vibrations and chafing. We validate our results with commercial grade microwave simulations (CST's Microwave Studio).

Typical interferences such as vibration and movement have caused wire fault identification systems to fail in practical application. Instead of trying to identify ways in which to reduce the effect of such disturbances, we embrace these disturbances as part of our model. In fact, it is because of these disturbances that we are able to infer the presence of soft faults along the wire.

Model based systems such as ours can then be used as the basis for a formal requirements analysis by identifying the types of information that need to be collected to resolve physical issues and outstanding questions. For example, very basic issues such as how often and when data should be collected depend upon a number of different variables and expected types of faults.